DOE/MC/31327--5064
UC--111

High-Pressure Coal-Fired Ceramic Air Heater for Gas Turbine Applications

DOE Contract No. DE-AC21-94MC31327

Technical Quarterly Report for May through July 1994

Program Management

Program Management: The preparation of the Management Report, Cost Plan, and Milestone/Schedule Plan were completed and submitted to DOE. A technical on-site review meeting was held at the Kennebunk Test Facility (KTF) on June 1.

Technical Papers: A paper entitled "Externally Fired Combined Cycle (EFCC) A DOE Clean Coal V Project - Effective Means of Rejuvenation For Older Coal-Fired Stations" was written by P. G. LaHaye (Hague International) and M. R. Bary (Black & Veatch). The paper was presented at the ASME Turbo Expo '94 at the Hague, Netherlands by P. G. LaHaye.

Task 2.1- Technology Development

Task 2.1.2 - CerHx Development:

Tube string component optimization is a continuing effort and significant part of the EFCC Development Program. Several of the tube-string components require materials that are either not commercially available or which have not adequately been tested at EFCC conditions. Significant materials testing is part of the development effort since the available literature on most materials used is either inaccurate or impertinent. The optimization effort includes exploring alternative fabrication methods that would reduce manufacturing time and cost.

Hex Inserts: Based on the experience obtained from the fabrication of the initial set of hex inserts, minor adjustments to the design of the hex inserts have been made that would greatly reduce the fabrication time. Also these modifications have lead the production of higher quality hex inserts. After several involved discussions with the component vendors, adjustments have also been made to the procurement specifications that will reduce fabrication time and possibly increase the performance of the high temperature joints.

Gaskets: The gasket manufacturing process has been streamlined resulting in an improved gasket production rate. The fabrication procedures have been updated to reflect these changes.

CPI tests have shown these gaskets perform very well at high temperatures, above 1000°F. CPI tests have been performed to determine the minimum "firing" temperature of these gaskets prior to initial pressurization, once installed in the tube string. CPI tests have also included statistical sampling of gaskets for quality control purposes.

CerHx tube string installation procedures require leak checks of each individual tube string to verify proper tube string assembly. The acceptable leakage rate criteria of each tube string, to verify proper assembly, were determined by CPI tests.

Ceramic Tubes: Efforts are continuing to optimize designs and fabrication processes for the ceramic tubes. These efforts include CPI tests and sequential failure tests.

Component Pressure Integrity (CPI) Tests: CPI test #23 was conducted on an 18 inch sample of material L tube. The test consisted of 217.5 hours of continuous exposure to a temperature of 1800°F and pressure of 150. The tube suffered no observable damage as a result of this test. However, after 24 hours of further high temperature exposure to a maximum temperature of 1600°F the tube reinforcement showed signs of degradation. Leakage rates for this test were less than 2 lbm/hr at 1800°F

The high temperature gaskets and hex inserts, currently utilized in the KTF CerHx, were installed for CPI test #23. The hex inserts and gaskets continue to display good performance.

Significant maintenance work was performed on the CPI test rig. Specifically, the filters on the high pressure lines were replaced, all pneumatically driven valves were serviced or replaced, flow measuring devices were calibrated and checked. Several base line tests were performed upon completion of this work

Sequential Failure (Ballistics) Tests: The development of tube reinforcement methods is continuing using the sequential failure test rig and a high speed video camera system. Several parameters important to the failure modes of the tube have been identified and quantified. This has been done for all the different ceramic tubes being considered for EFCC. A knowledge of these parameters is necessary not only to determine the effectiveness of the reinforcement technique but also as a basis for further reinforcement optimization.

Transducers: Transducers inside the ceramic tubes serve to enhance the heat transfer and improve overall heat exchanger efficiency. A significant portion of the transducer development effort has focused on material choices and performance requirements. Currently, the design of the transducer continues to be optimized.

A pressure drop test rig was designed and constructed. The pressure drop experiments are conducted as each new transducer prototype is fabricated. Preliminary data indicate that the roughness of the ceramic tubes and slight variations in tube dimensioning contribute greatly to the pressure drop on the tube-side flow. As a result of the combined effect, the pressure drop has been noted to be over a factor of two larger than anticipated. This is significant enough to have an impact on future transducer designs.

Task 2.2- Fuel and Fuel Handling

Task 2.3.2 - Procure Coal Handling System:

Coal Handling System: An internal design review of the coal handling system was conducted. Based on this review and suggestions from Mr. Parsons of DOE METC, it was concluded that direct coal feeding from the pulverizer to the combustor, especially at low fire rates, could produce unsteady coal flow and non-uniform coal particle size distribution. Designs for the coal handling system to accommodate this change are being revised and are nearing completion. Specifications for the long lead components have been completed.

Natural Gas Fuel System: Assembly and installation of the fuel train, acquired as GFE, was completed. Operational and checkout tests have also been successfully completed.

Task 2.3 - Burner and Combustion chamber

Task 2.3.2 - Construct Combustion Chamber:

Construct Complete Combustion Chamber: Construction of the combustion chamber was completed. This includes installation of internal insulation for the first and second stages, and installation of the "choke" ring separating the first and second stages.

The plunger valve assembly was completed. The instrumentation flanges and site ports were also installed.

Task 2.4 - Heat Exchanger Development

Task 2.4.1 - CerHx Tube-String Components:

Hex Inserts: Fabrication of both the male/female and female/female hex inserts were completed.

Gasket Production: Fabrication for the first assembly of the CerHx tube-string were completed. Production of additional gaskets for upcoming tests continues.

"Check Valve" System: Final designs for the check valve system for the tube-string were completed.

Task 2.4.2 - CerHx Assembly:

CerHx Assembly: Installation of the support blocks and hex restraints were completed. Tests were conducted in the Decompression Test Rig to validate the design of the insulating tubes for the hot header.

CerHx Cooling System: Designs for the CerHx cooling system were reviewed and will be finalized during the next quarter. The cooling system provides the required air cooling for the hex restraints and upper tube sheet.

Task 3.1 - Test Facilities

Task 3.1.1 Test Facility and Support System Design/Construction:

High Pressure Air Supply System: Final designs for the piping and supports were completed. The internal insulation materials were received and fabrication initiated. Design of the liners for the double-walled piping section were completed. The liner material was received and fabrication initiated.

Combustion Air System: The internal insulation for the combustion air system was received. Design for the Bypass piping section was completed and fabrication initiated. The combustion air system control valves were received and installation initiated.

Exhaust Breeching: Materials for the expansion joint between the HRSG breeching and the ID fan was received and installation initiated.

ID Fan: Design for the support of the ID fan was completed. Fabrication and installation of the ID Fan and ID Fan support was completed. Checkout operation of the ID Fan was also completed.

Controls & Instrumentation: Installation of the control system for the "dry-out" tests have been completed. Designs and specifications of the data acquisition system is nearing completion.

CerHx Tube-String Assembly: Assembly of the MIET was initiated and is approximately 50% complete. The assembly procedure includes pressure testing (up to 15 psig) the individual tube strings as each individual assembly is completed.

Task 3.2 - Testing and Analysis

Task 3.2.1 Systems Test:

Integrated Test Plan: Initial checkout and "dry-out" tests will be performed during the next quarter. The dry-out procedures and required temperature schedules for proper refractory dry-out are in the process of being developed. The detailed test procedures for these initial tests will be completed and submitted to DOE during the next quarter.